P1-036

Tungsten Erosion in the All-Metal Tokamaks JET and ASDEX Upgrade

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*See the Appendix of F. Romanelli et al.,Proceedings of the 23rd IAEA Fusion Energy Conference 2010, Daejeon, Korea

Overview - Summary

The tungsten source in the outer divertor of JET in its current all-W configuration and Be main wall has been quantified mainly during L-mode plasmas and compared to AUG Data both gained from local spectroscopy. Results so far show differences between AUG and JET based on impurities in the plasma changing the sputter behavior. This stresses the need for detailed analysis of the divertor impurity composition and detailed modeling in the future analysis. The H-Mode examples indicate at ELM dominated sputtering and a rather low averaged sputtering yield in general. Nitrogen seeding can change the divertor conditions significantly either increasing W sputtering or suppressing it due to local cooling, JET and AUG behave identical. All together it is clear that by having low divertor temperature or a beneficial impurity composition sputtering can be controlled and is rather low as expected in an all metal environment.

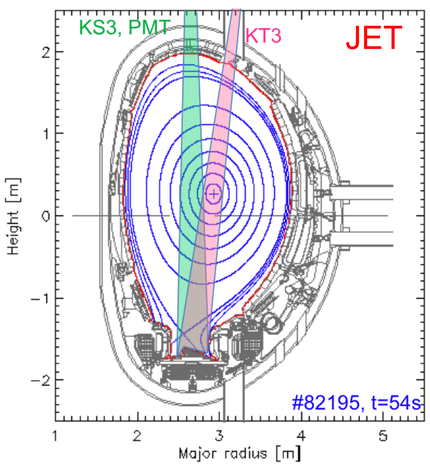
Introduction & Diagnostics

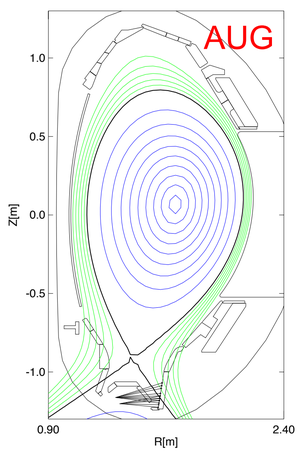
A full tungsten (W) divertor is proposed for plasma and power exhaust in ITER. Because of the high specific radiation power of W at fusion plasma temperatures and correspondingly low permitted concentrations of <O(10^{-5}), the quantification of W sources and transport from the divertor into the core are important issues for reliable tokamak operation.

The ITER-like Wall at JET with beryllium (Be) in the main chamber and W in the divertor as well as the all W ASDEX Upgrade (AUG) are suitable for studying ITER-relevant aspects of W-erosion as well as power-handling.

In both machines the divertor is bulk tungsten or tungsten coated, while the main wall differs from Be to all W in ASDEX Upgrade

- Divertor-spectroscopy in the visible is covering in both machines the outer Strikpoint position
- Langmuir probes are available to measure local plasma parameters

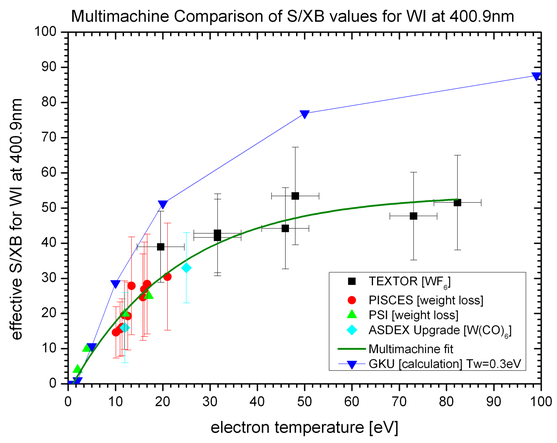




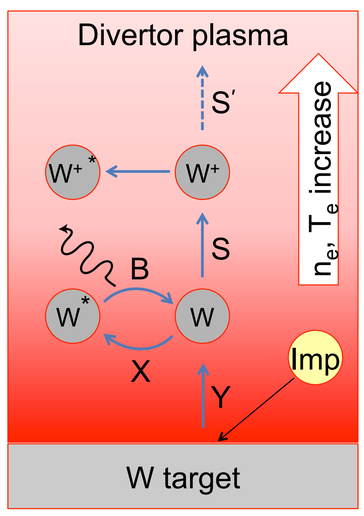
S/XB - Values(WI)

Particle fluxes based on spectroscopy require atomic data to calculate the local W source from photon fluxes. A multi machine fit based on spectroscopic measurements for the most prominent WI line (400.9nm) are used here.

$$\Gamma_{W^0} = \frac{S}{XB}(T_e)\Gamma_{h\nu}$$

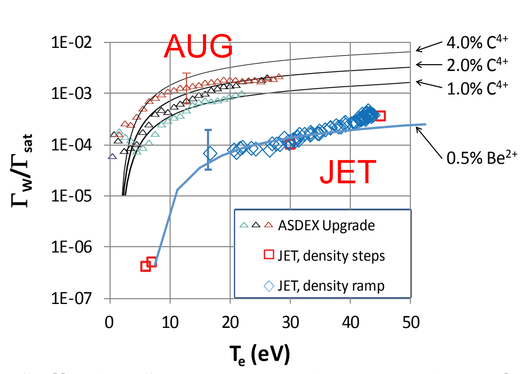


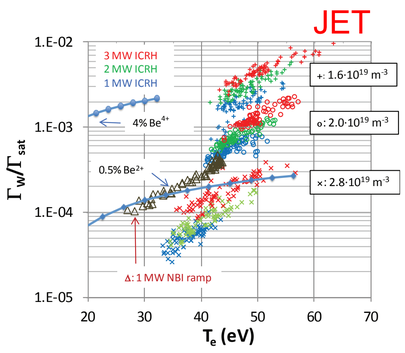
$$\frac{S}{XB}(T_e) = 53.7\left(1 - 1.04\exp\left(-\frac{T_e}{22.1}\right)\right)$$



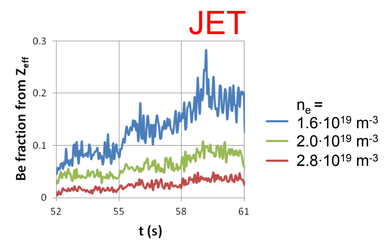
Results

L-Mode



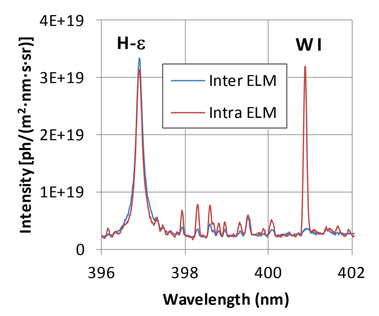


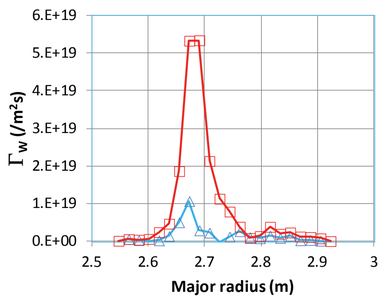
- The "effective" erosion yield is up to a **factor 100** lower in the JET Divertor due to **Beryllium being the main sputtering ion** (CX neutrals do contribute) compared to AUG with C dominant
- Beryllium content depends on global plasma parameters such as density and input power - change in **impurity composition effects the sputter yield**



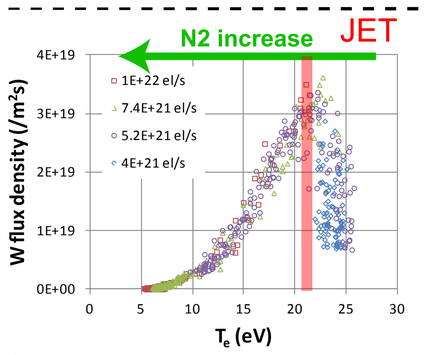
H-Mode

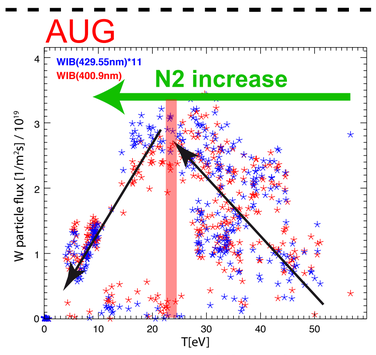
- In pulses with low ELM frequenzy (10Hz) inter- and intra- ELM spectra as well as divertor emission profiles can be observed
- The tungsten erosion yield in typical H-Modes independent of fuelling and ELM frequnecy at I_P=2.0A B_T=2.0T is (4.5 +/- 1.9) 10^{19} for P_{NBI}=10MW and for P_{NBI}=6MW ((3.2 +/- 0.6)10^{19}
- The sputter yield is below what is observed in L-Mode
- The ratio between inter- and intra-ELM is ~5 , the sputtering being dominated by ELMs.
- The observed behavior is consistent with AUG results

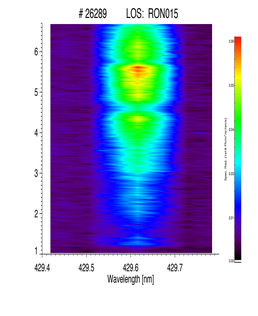




1MW L-MODE N2 Seeding







- Depending on the nitrogen levels on can achive either increased W erosion or near complete suppresion
- At low nitrogen levels the divertor temperature remains close to the initial levels with the sputtering increasing significantly
- At high nitrogen levels the Te drops well below 10 eV in both AUG and JET suppressing the W erosion in the divertor - the tip over is in both machines at 20eV

JET as well as ASDEX Upgrade show similar behavior with respect to W sputtering taking into account the impinging impurities: C/Be/N

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